γ-Jet Studies

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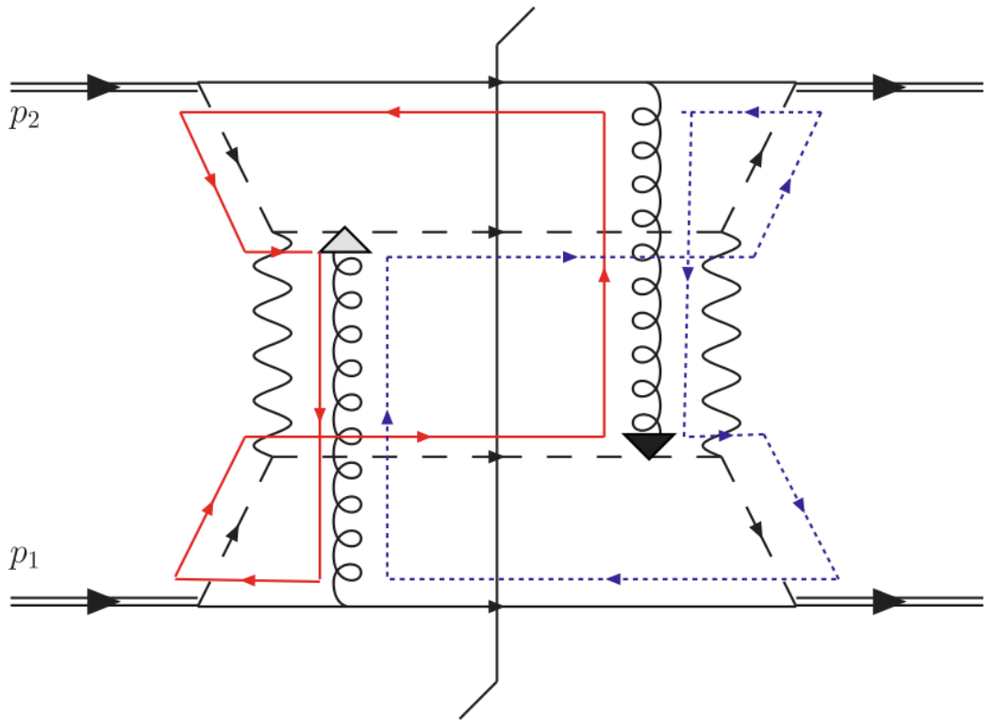
Physics Motivation

- PRD 81,094006 (2010) predicted factorization breaking in p+p—>h_1+h_2+X

- Nonperturbative PDFs and FFs quantum mechanically correlated across hadrons

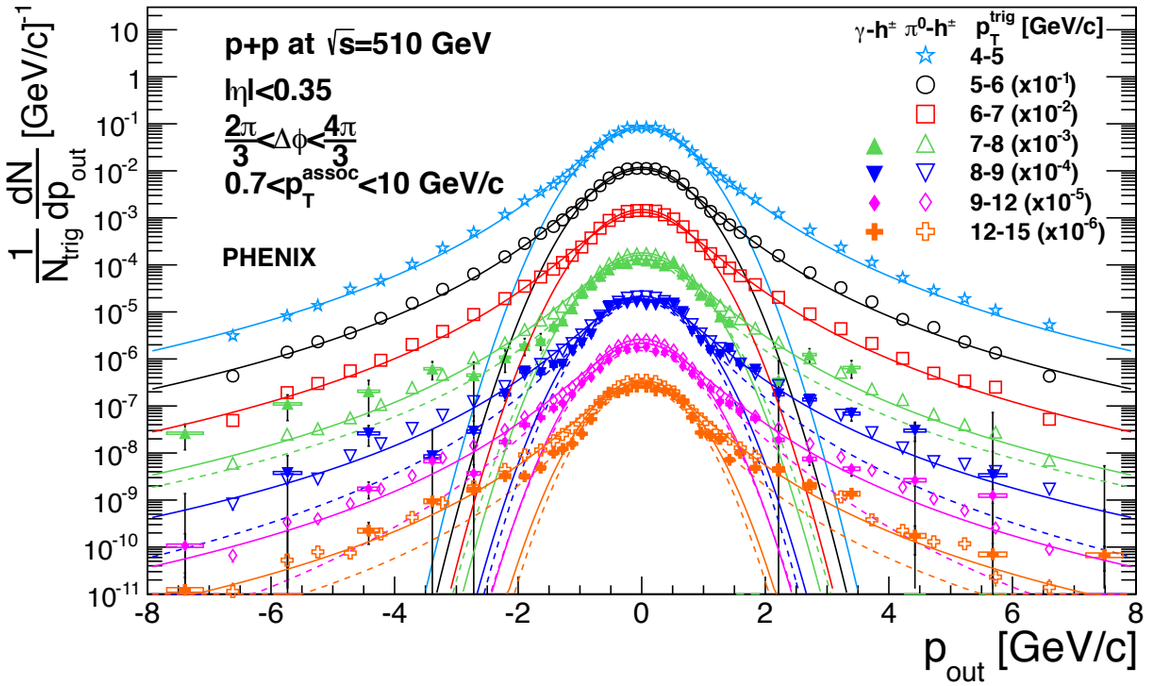
- Important check of understanding of perturbative QCD in a transverse momentum dependent framework - results from same physical mechanism leading to Sivers sign change

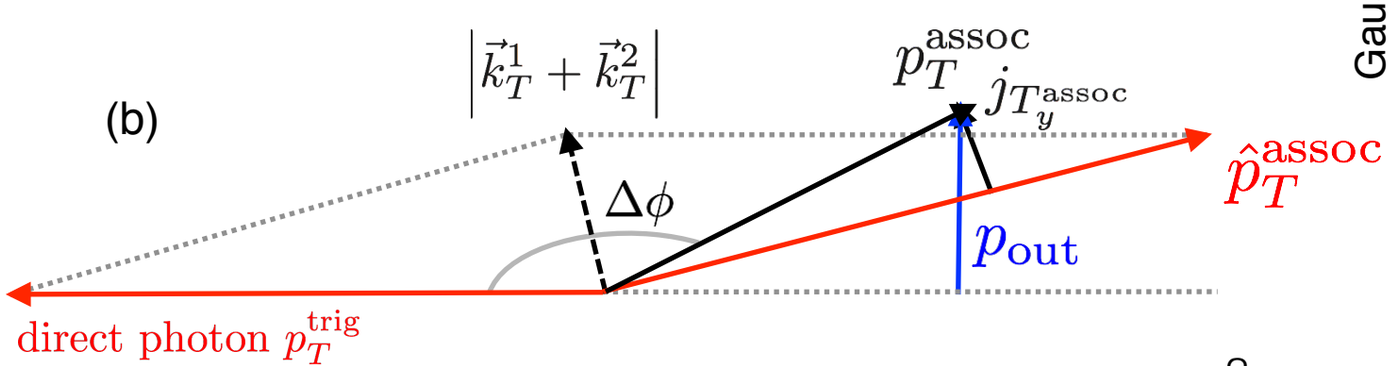


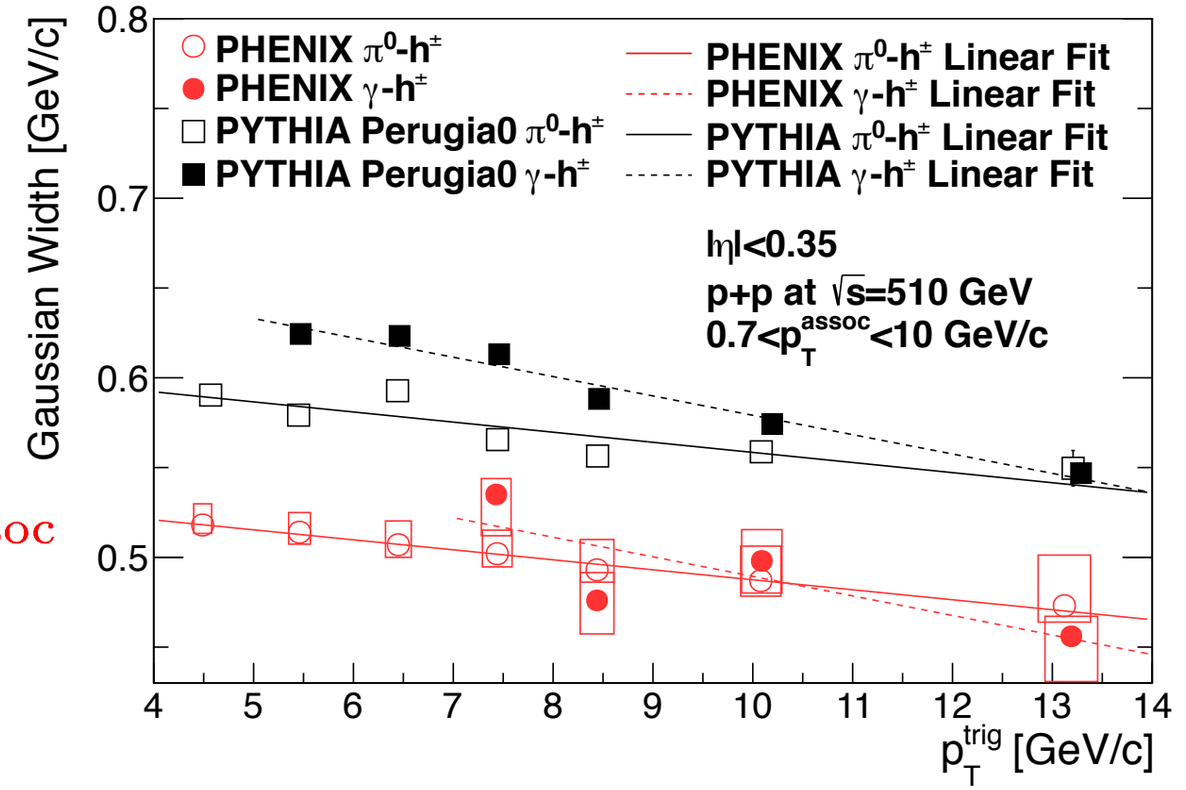
- Perturbative evolution predicts that momentum widths sensitive to nonperturbative transverse momentum should increase with increasing hard scale
- Confirmed in Drell-Yan and Semi-inclusive deep-inelastic-scattering

Physics Motivation

- PHENIX recently submitted arXiv:1609.04769, dihadron and direct photon-hadron correlations
- Measurements show opposite trend from perturbative evolution prediction
- Ideal measurement is photon-jet: can study factorization breaking with control over fragmentation
- While more “cold QCD” focused, there are many similarities and avenues of potential questions to jet structure and fragmentation







Method

- Used Dennis' γ-jet HEPmc PYTHIA8 files from sPHENIX collaboration meeting and ran them through GEANT4 sPHENIX detector with Fun4All_G4_sPHENIX.C

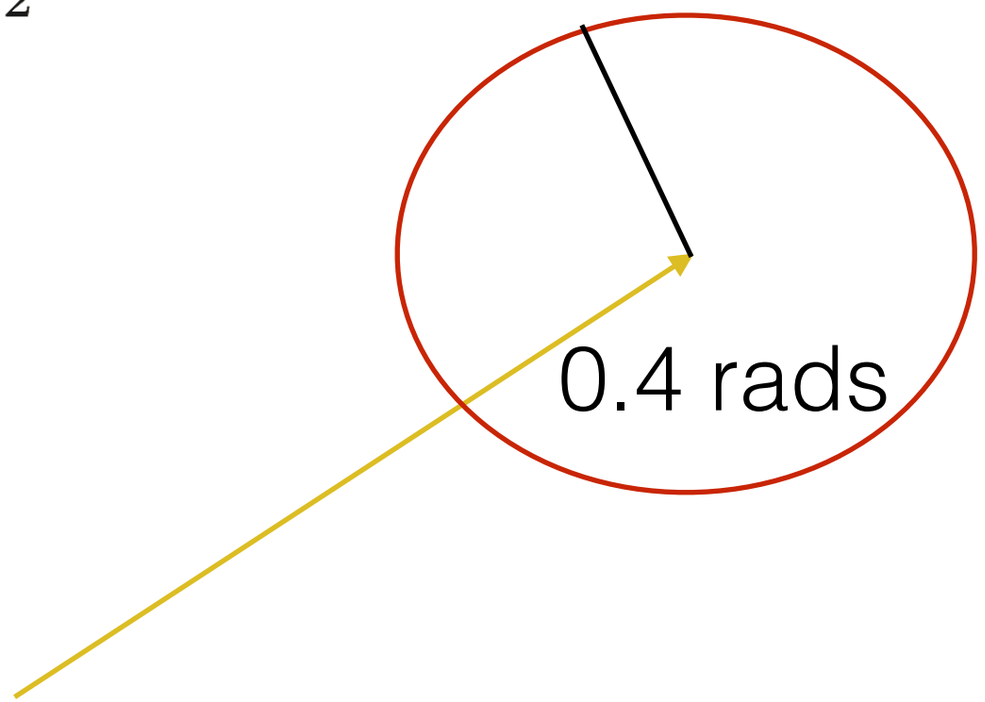
- Using my analysis code Photon-Jet (in GitHub under PhotonJet) which produces trees of photon-jets, photon-hadrons, etc. to compare reconstructed objects to truth objects and their effects on observable p_{out} and angular correlations

Isolation Cut

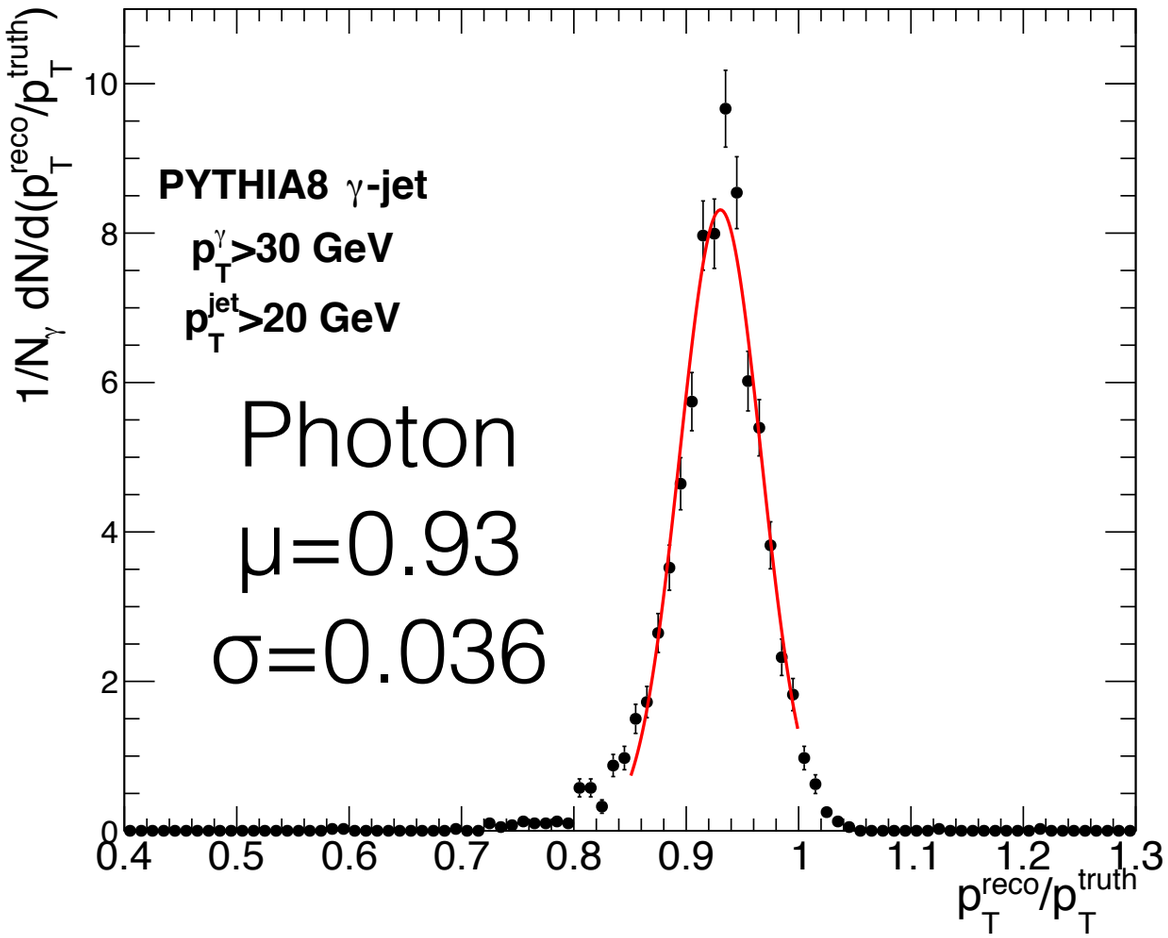
- Studying effect of isolation cut on direct photon
- Current requirements:
  - Isolation cone of $R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$ 0.4 radians
  - Entire isolation cone region restricted to be within |η|<1

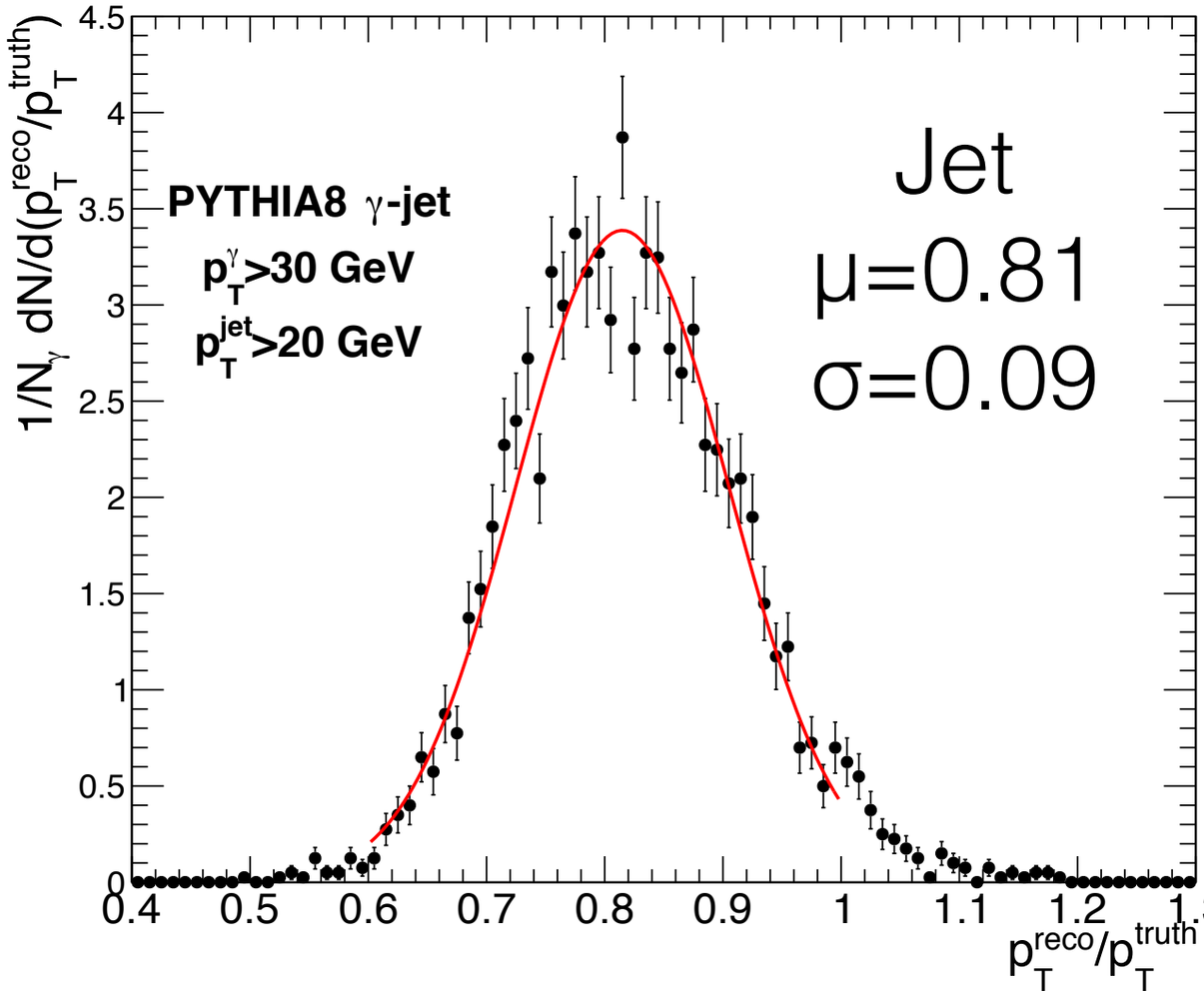
$$0.1 \times \Sigma(E_\gamma + p_T^{tracks}) < E_\gamma^{iso}$$

- Results in ~4000 of the 10000 photons
- This can obviously be altered depending on isolation cone size, energy restriction, etc.



γ and Jet p_T



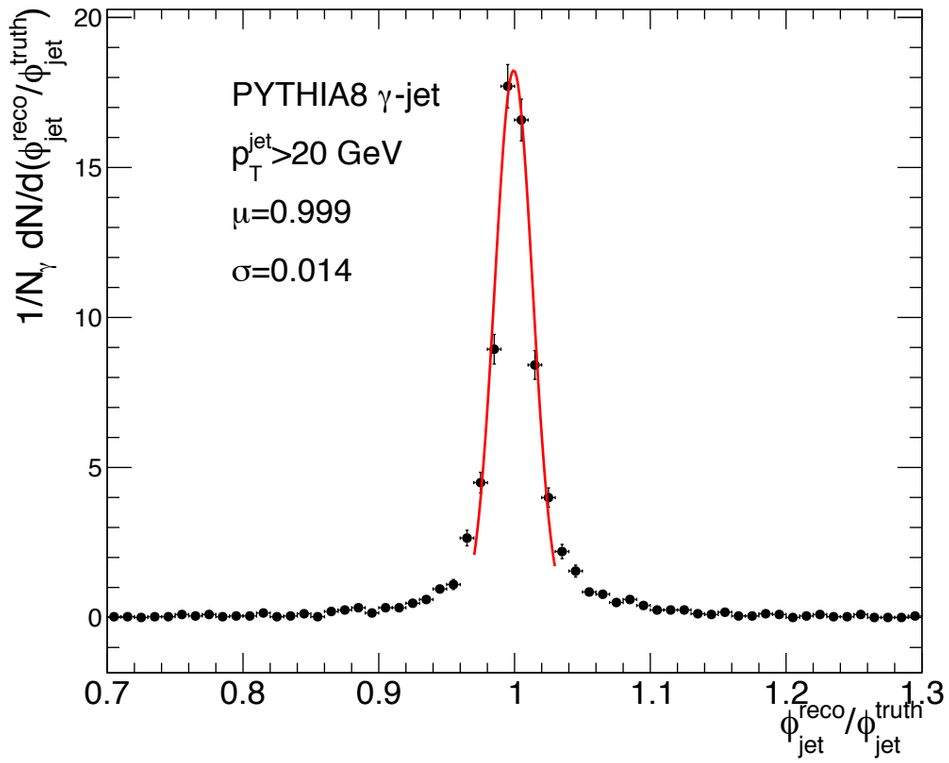


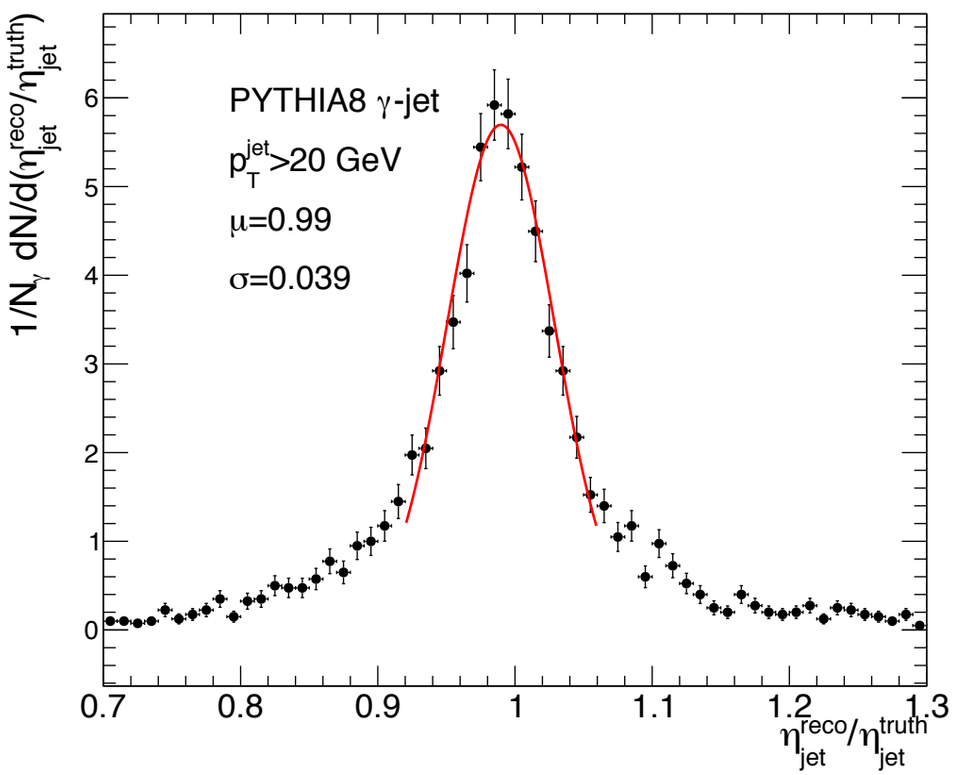
- Find similar results for isolated direct photons to Dennis' studies for all direct photons

sPHENIX γ-Jet

- To measure $p_{out}=p_T^{assoc}\sin(\Delta\phi)$, need good resolution of jet angles and p_T

- ϕ and η resolution ~0.02-0.04

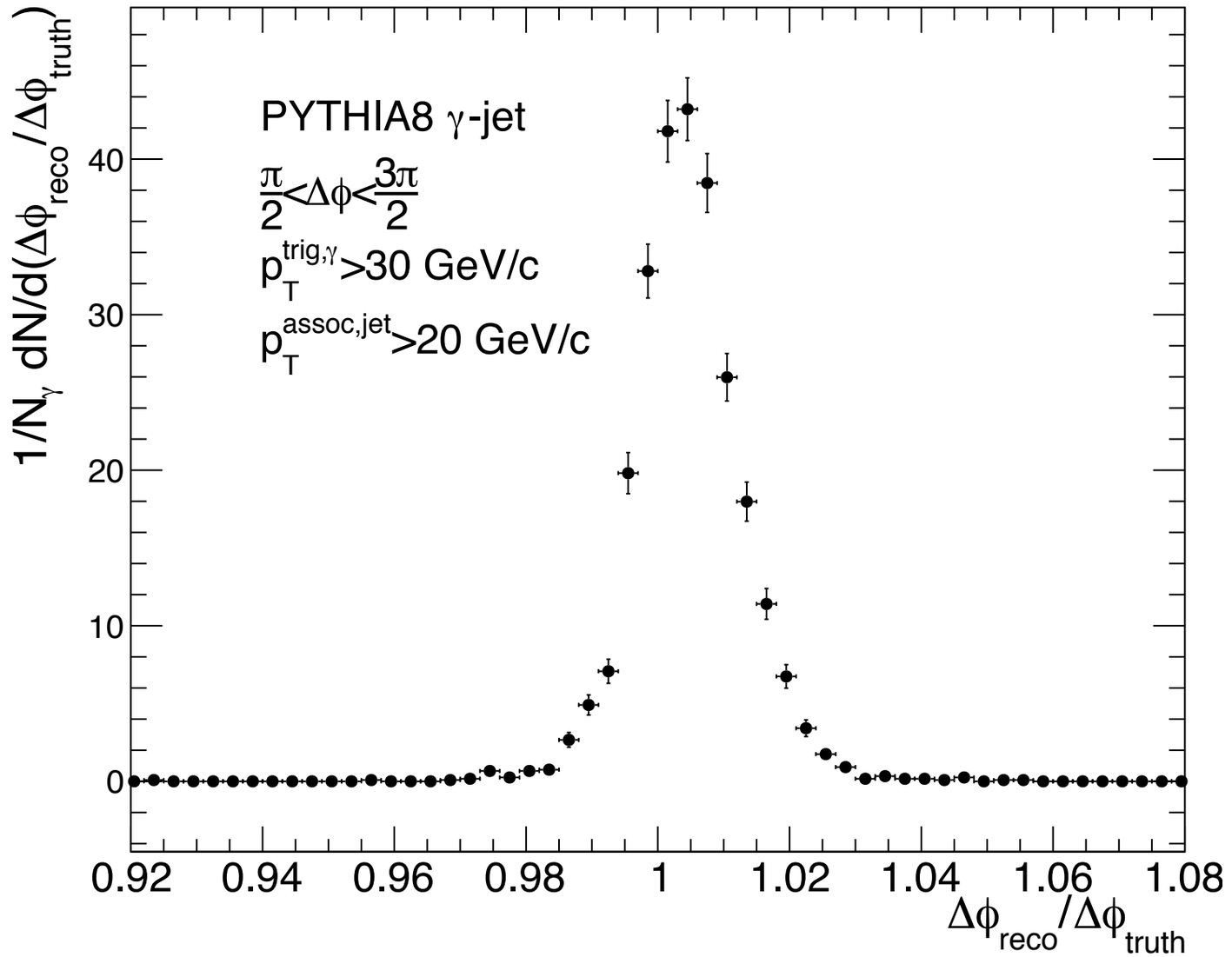




Δϕ Resolution

- Δϕ resolution appears to be pretty good. Slightly offset from 1, perhaps some acceptance effects

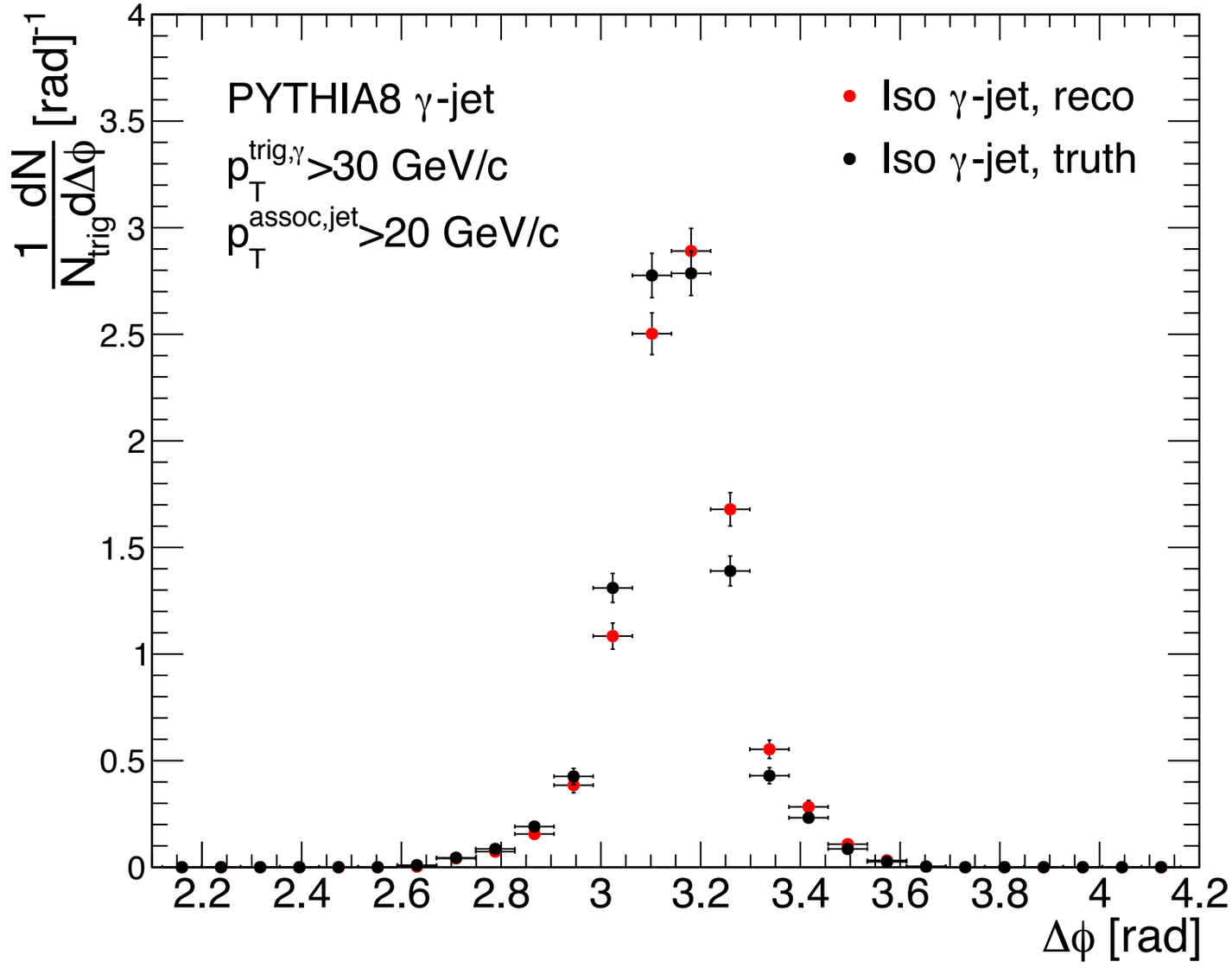
- $\Delta\phi = p_T^{\text{trig, }\gamma} - p_T^{\text{assoc,jet}}$



Δϕ Response

- Iso photon-jet Δϕ distributions compare reasonably with truth distributions

- Binning is symmetric about π, so some acceptance effects in the reconstructed distribution are apparent

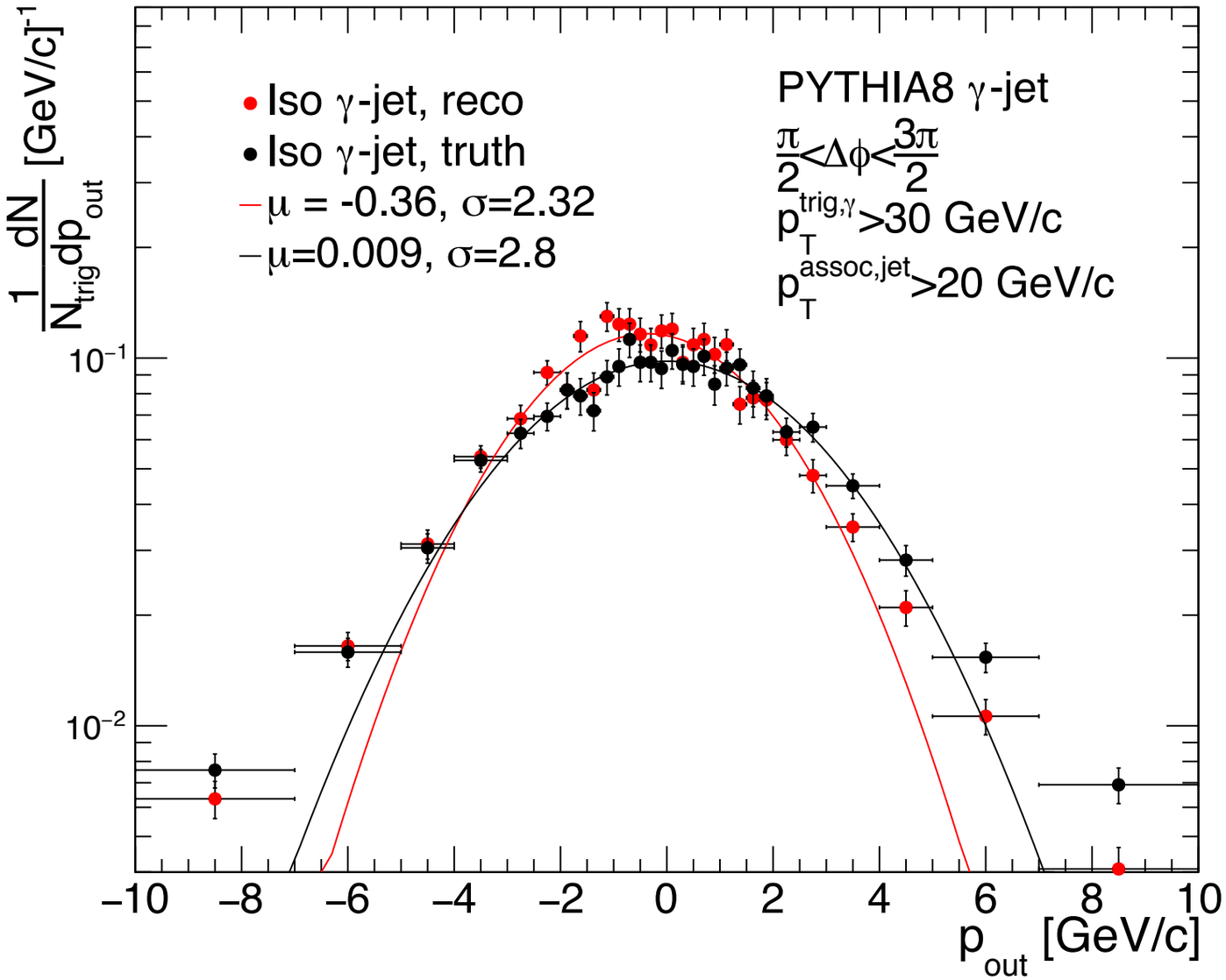


p_{out} Response

- Expect that mean of Gaussian should be centered at 0 - displacement follows from Δϕ distribution being asymmetric

- Reco not acceptance or jet response corrected

- At large p_{out} appears that we will have the statistics to differentiate between nonperturbative k_T and perturbative k_T



Summary

- Interested in studying γ-jet at sPHENIX to continue investigation of possible factorization breaking in p+p collisions

- Working with Dennis' γ-jet simulations (for now) and looking at isolation cut. So far shows no major effect/difference from Dennis' studies

- To Do

  - Possibly do some embedding studies - or study sPHENIX ability to reconstruct direct photon-jet events in all QCD hard scattered events

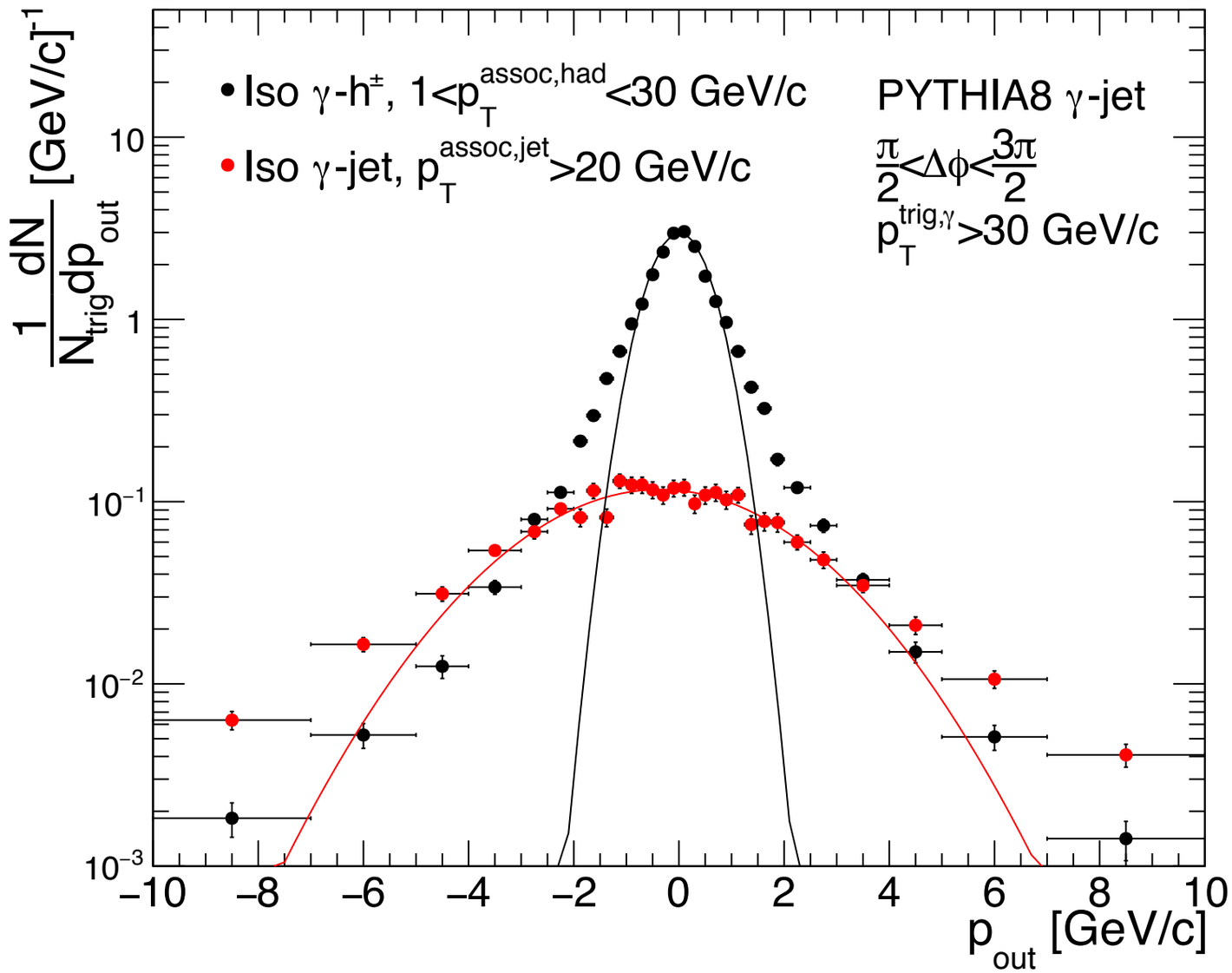
  - Generate PYTHIA files for lower momentum direct photons - would like to look at a range of p_T^{γ} ideally as low as 10 GeV/c (can we reconstruct a jet with ~7 GeV/c p_T?)

Back Up/Extras

Reco p_{out} Distributions

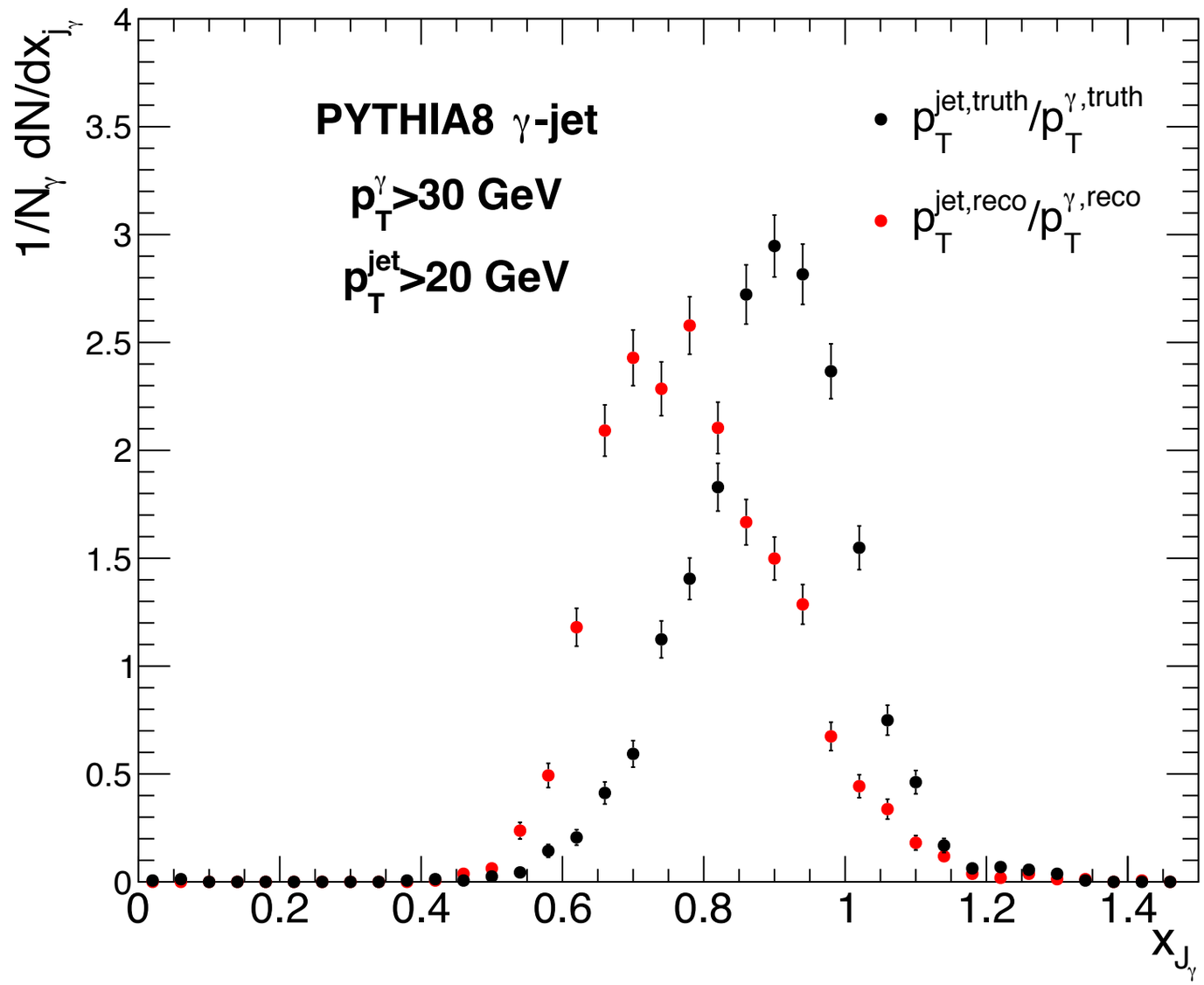
- Fragmentation greatly draws in transverse momentum dependence

- γ-jet sensitive to only initial-state k_T while γ-hadron is sensitive to initial-state and final-state k_T and j_T

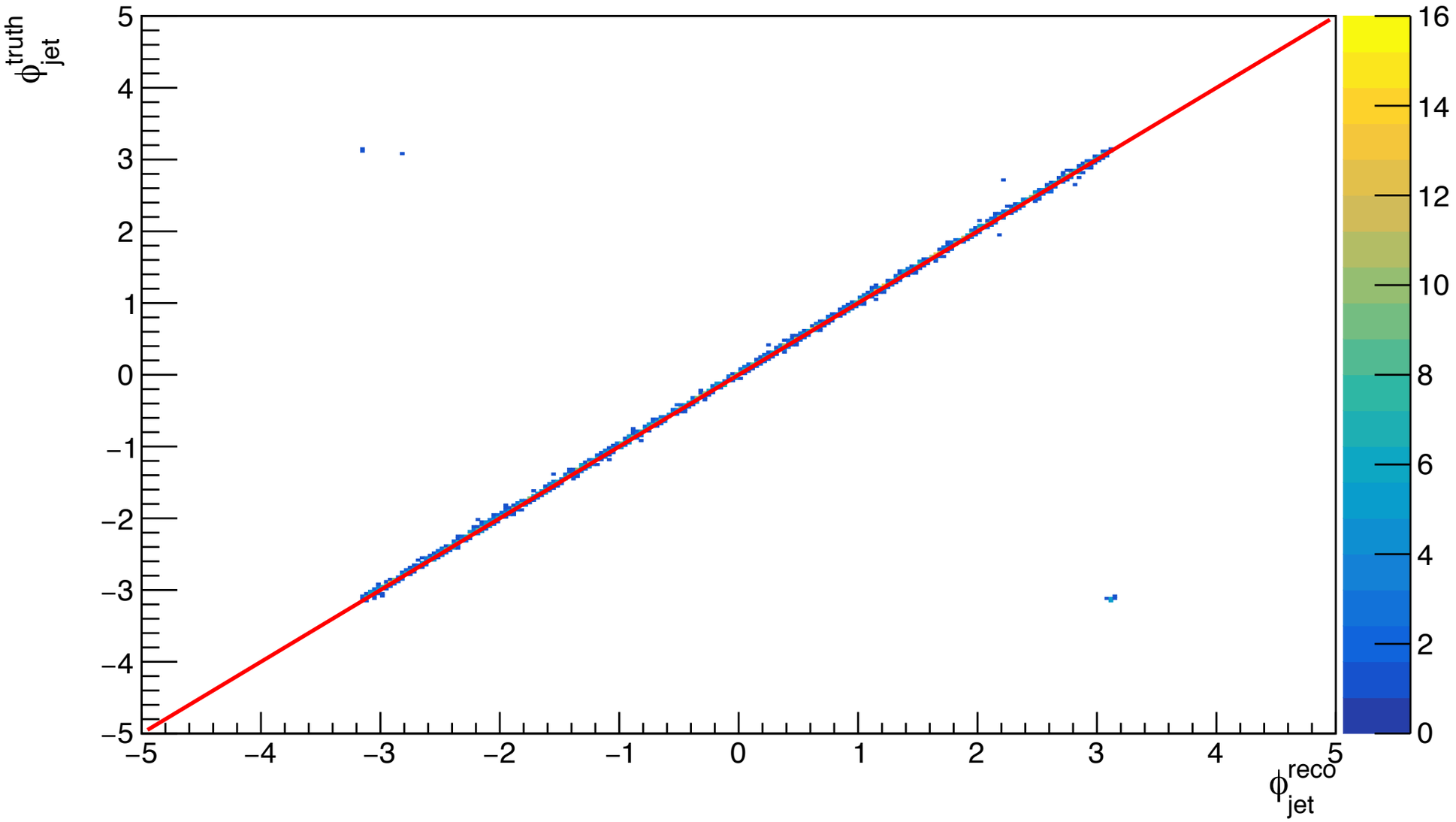


X_J Distributions

- x_J distributions similar in reconstructed vs. truth
- Reco not corrected for detector photon/ jet response



ϕ Residual


ϕ_{jet}^{truth}
5
4
3
2
1
0
−1
−2
−3
−4
−5
−5
−4
−3
−2
−1
0
1
2
3
4
5
ϕ_{jet}^{reco}
16
14
12
10
8
6
4
2
0